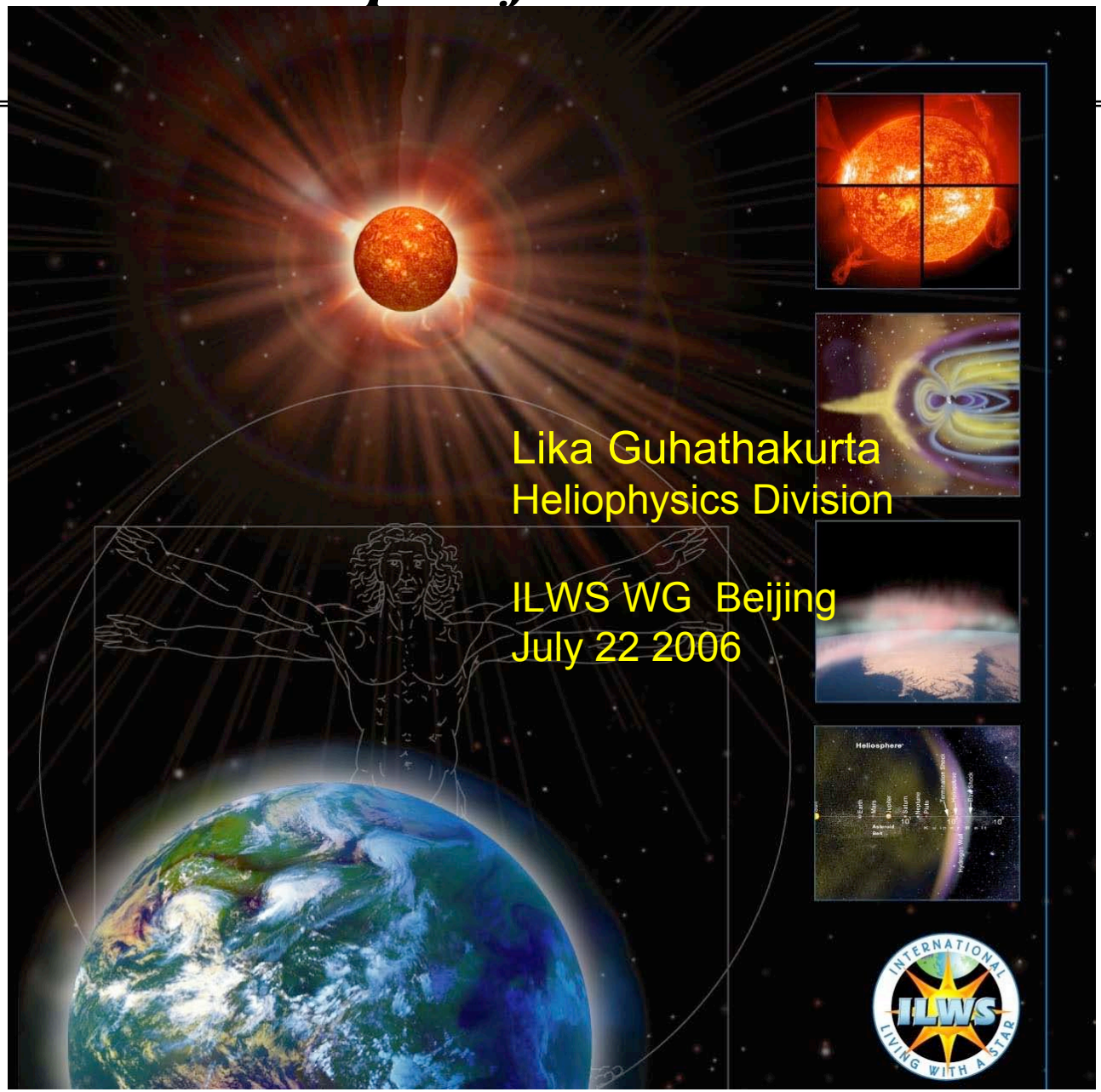
Report from NASA



2006 NASA Strategic Plan

NASA's Strategic Goals

Strategic Goal 1: Fly the Shuttle as safely as possible until its retirement, not later than 2010.

Strategic Goal 2: Complete the International Space Station in a manner consistent with NASA's International Partner commitments and the needs of human exploration.

Strategic Goal 3: Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration.

Strategic Goal 4: Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement.

Strategic Goal 5: Encourage the pursuit of appropriate partnerships with the emerging commercial space sector.

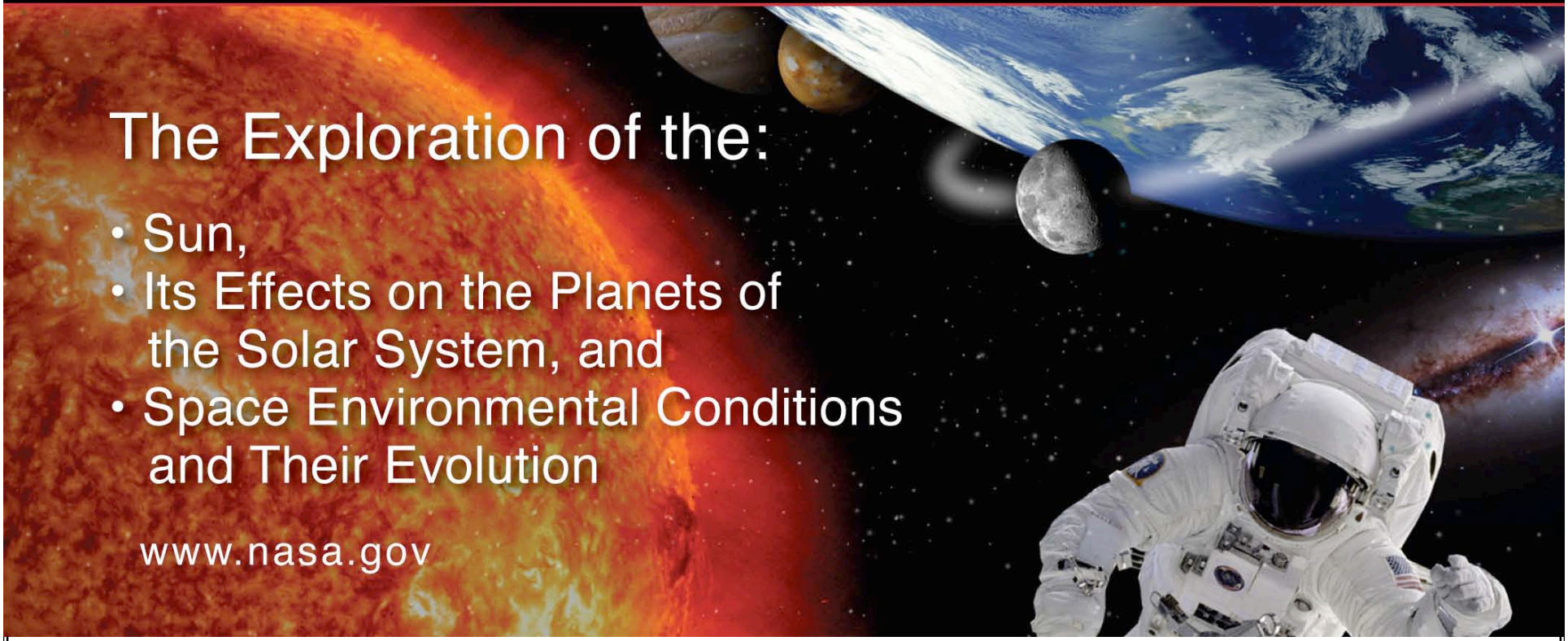
Strategic Goal 6: Establish a lunar return program having the maximum possible utility for later missions to Mars and other destinations.

http://www.nasa.gov/pdf/142302main_2006_NASA_Strategic_Plan.pdf

A New Noun for Science

National Aeronautics and Space Administration

HELIOPHYSICS DIVISION
Science Mission Directorate



Strategic Goal 3

- Sub Goal 3A: Study Earth from Space to advance scientific understanding and meet societal needs. (Earth Science Division)

- **Sub Goal 3B: Understand the Sun and its effects on Earth and the Solar System .** (Heliophysics Division)

- Sub Goal 3C: Advance Scientific Knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as human explores space. (Planetary Science)

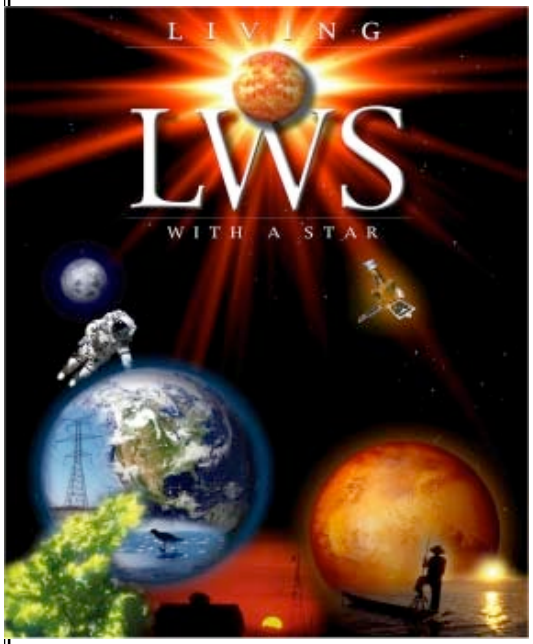
- Sub Goal 3D: Discover the origin, structure, evolution Astrophyand destiny of the universe, and search for Earth-like planets. (Astrophysics Division)

Science Missions


Heliophysics Division Roadmap Available
On Line
http://sec.gsfc.nasa.gov/sec_roadmap.htm

Heliophysics Division's Human Capital and Infrastructure

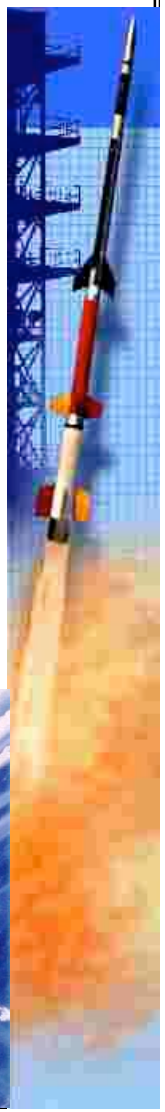
So that we may develop/maintain space plasma and space weather prediction / mitigation expertise, it is vital to provide a broad range of competed funding opportunities for the scientific community

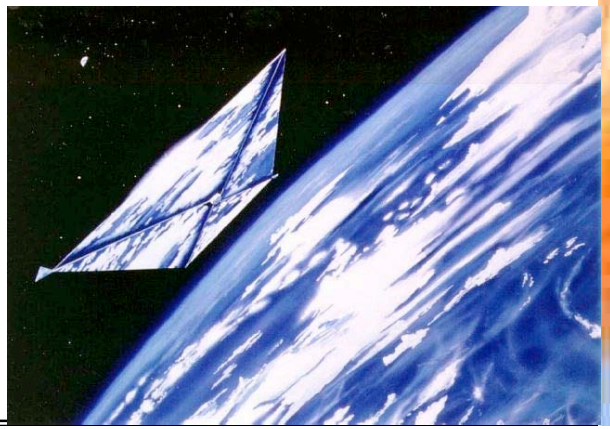


Science Investigations:
- Solar Terrestrial Probes (STP)
- Living with a Star (LWS)
- Explorer Program
- Discovery Program
- Heliophysics Great Observatory

Research Programs:
- Research and Analysis Grants
- Guest Investigator
- Theory Program
- Targeted Research & Technology
- Project Columbia

Enabling Capabilities:
Sounding Rocket/Balloon Program
Advanced Technology Program
Education and Public Outreach





Develop IT, Computing, Modeling and Analysis Infrastructure
- Virtual Observatories

Low Cost Access to Space
- Science, Training, & Instrument Development

E/PO to Attract Workers to Earth-Sun Systems Science

Maintain Multiple Hardware & Modeling Groups
- Strengthen University Involvement in Space Hardware Development
- Facilitate and Exploit Partnerships
- Interagency and International

-**Upgrade DSN to Collect More Data Throughout the Solar System**

Heliophysics Division's External Partnerships

Partnership Forums:

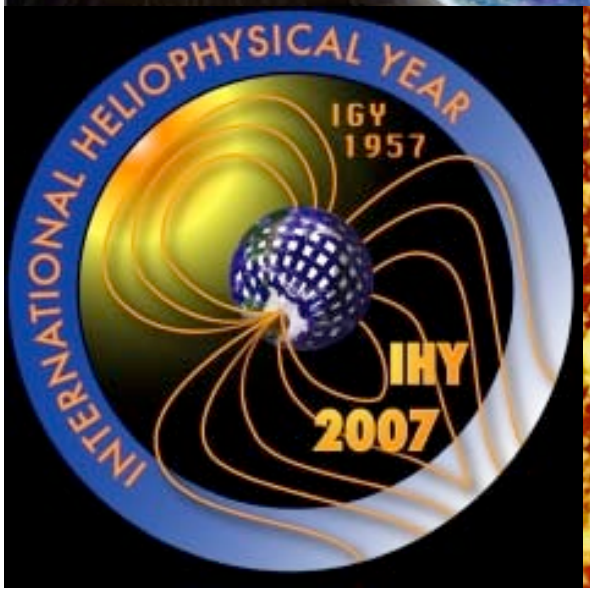
- International Living with a Star
- International Heliophysical Year
- Enabling Space Weather Predictions for the International Space Environment Service
- National Space Weather Program

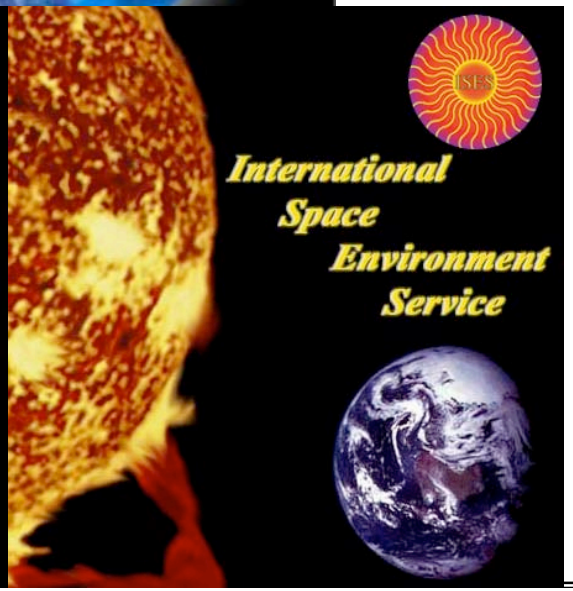
Current Partnership Missions:

- Ulysses (ESA)
- SoHO (ESA)
- Cluster (ESA)
- Geotail (JAXA)
- Solar-B (JAXA)

Future Partnership Missions:

- Solar Orbiter (ESA)





National Partners:

- National Science Foundation
- National Oceanic and Atmospheric Administration
- NOAA Space Environment Center
- Department of Commerce
- Department of Defense
- Department of Transportation
- Department of Energy
- Department of the Interior

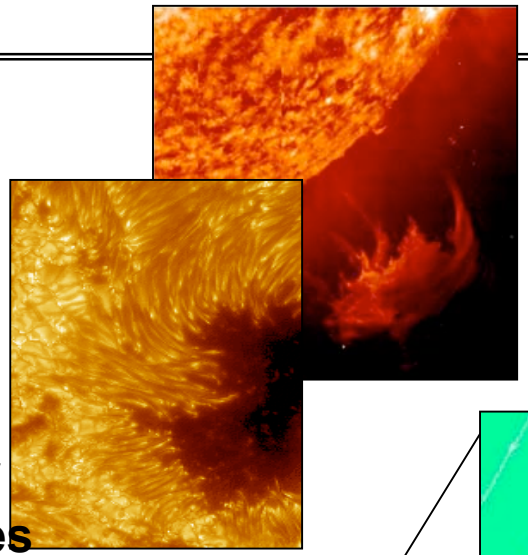
- International Space Environment Service
- NOAA / World Warning Agency in Boulder

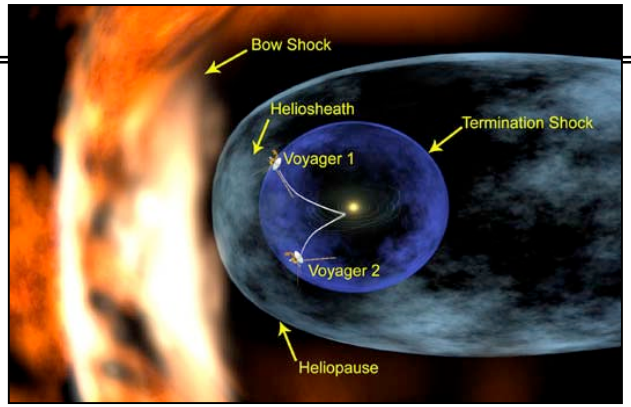
External and Internal Factors
Heliophysics Division

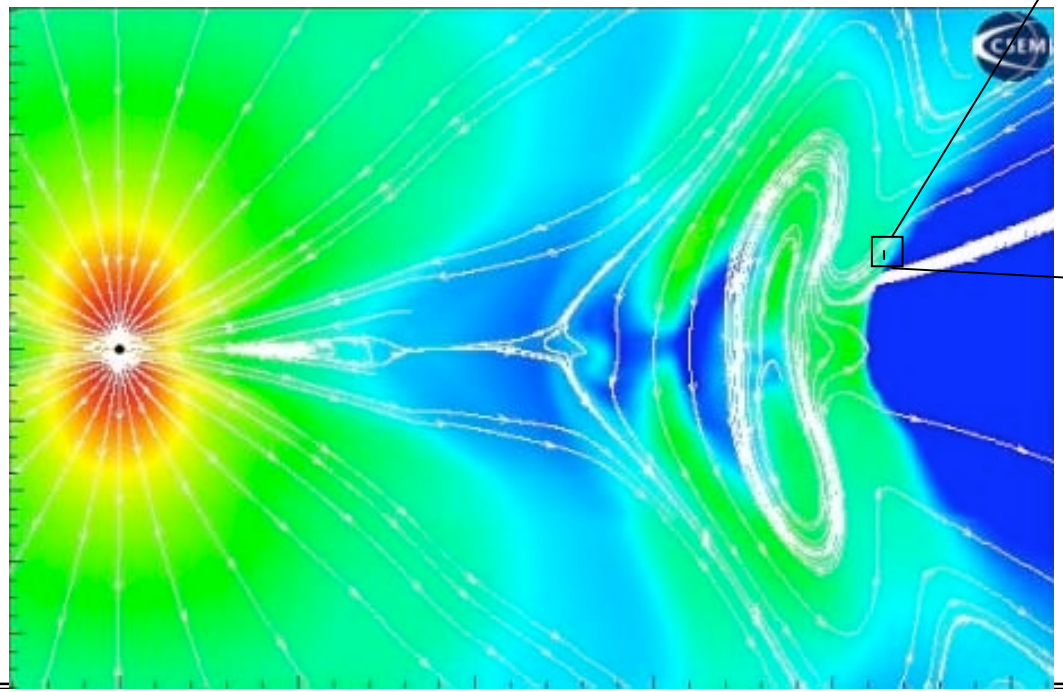
- Our society needs space weather knowledge to function efficiently
- Human beings require space weather predictions to work safely and productively in space
- We are poised to provide knowledge and predictive understanding of the system

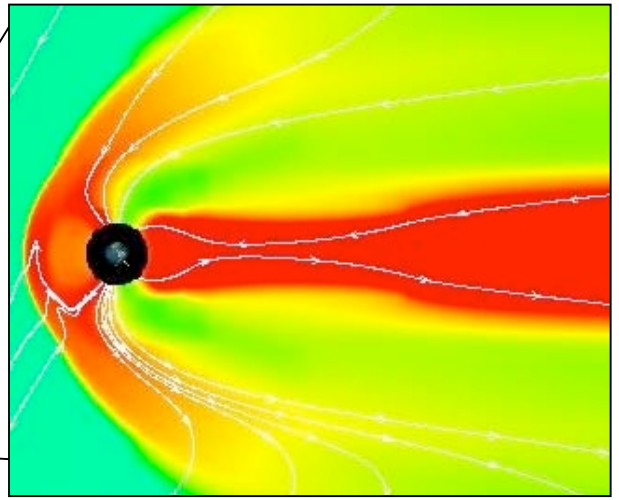
Nature of the Challenge

- A quantitative, predictive understanding of a complex system
- Microphysical processes regulate global & interplanetary structures
- Multi-constituent plasmas and complex photochemistry
- Non-linear dynamic responses



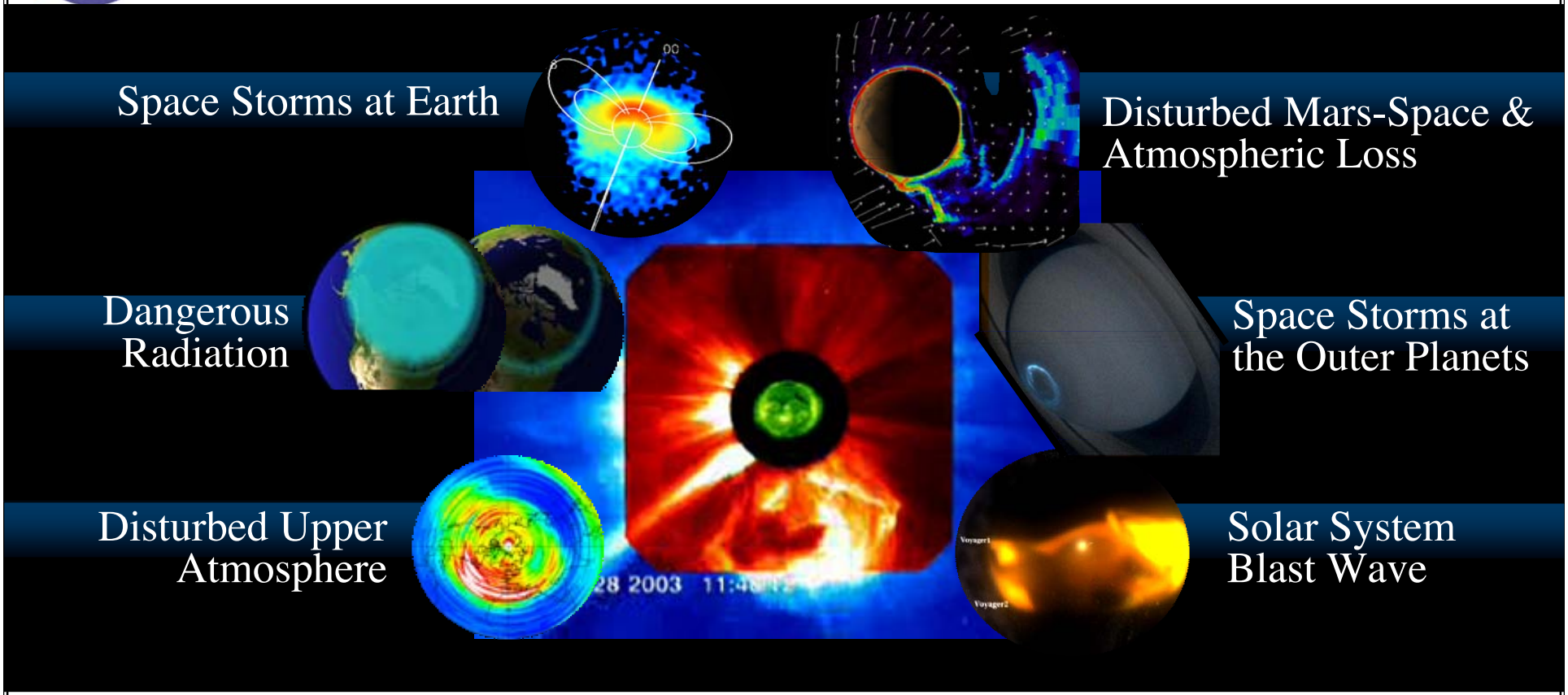






- Integration and synthesis of multi-point observations
- Data assimilative models & theory
- Interdisciplinary communities and tools

We Have Already Begun!



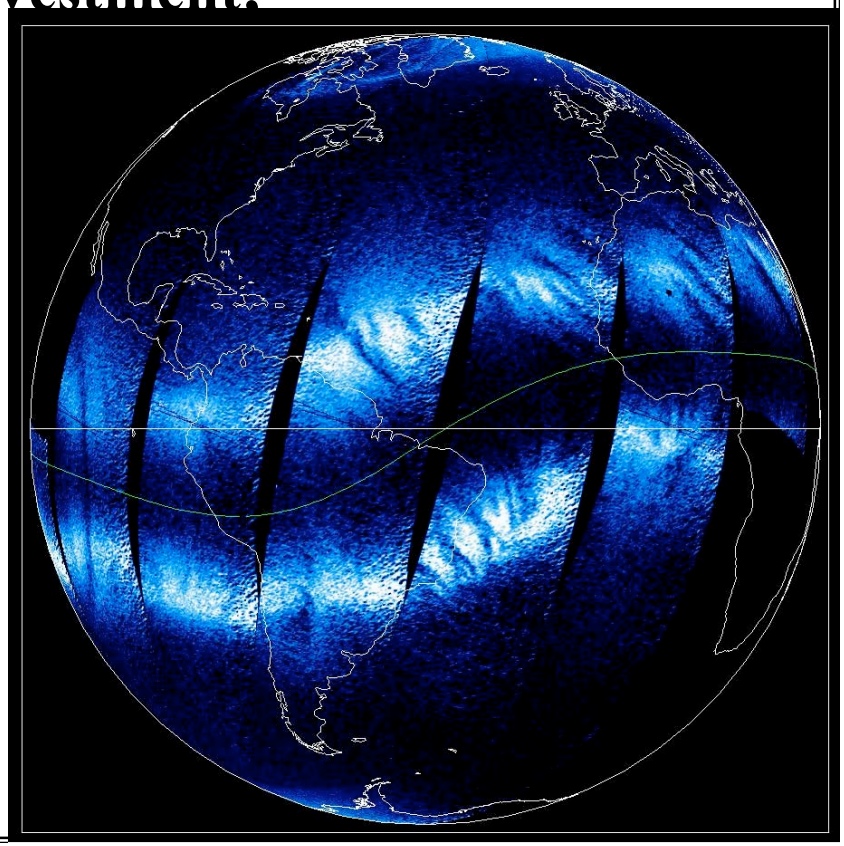
- **Current missions provide a prototype "Great Observatory", providing a first look at the system level view of this complex system**
- **Theory, modeling, and observational tools now exist or can be developed to yield both transformational knowledge of this system and provide needed tools and space weather knowledge for human exploration and societal needs**

The 5th Great Observatory

- **World's largest and most expensive plasma physics laboratory**
- **Enabled investigation of the Sun's influence on Earth and the solar system~ $5B investment:**

~ $100M/yr annual budget

- 13 magnetometers
- 9 E-field analyzers
- 15 plasma analyzers
- 31 energetic particle spectrometers
- 4 neutral particle imagers
- 9 RF spectrometers
- 3 visible imagers
- 3 doppler interferometers
- 8 UV and x-ray imagers



The HP Data Environment

- Data from the Great Observatory reside in a distributed environment and are served from multiple sources.

- Multimission Data Centers
  - Solar Data Analysis Center
  - Space Physics Data Facility [CDAWeb, OMNIWeb, etc.]
  - The Community Coordinated Modeling Center

- Mission-level active archives: e.g. ACE, TIMED, TRACE, Cluster, etc.
- Much of our data are served from the individual instrument sites.

- We are moving into a new data environment of
  - Virtual Observatories for convenient search and access of the distributed data, and
  - Resident Archives to retain the distributed data sources even after mission termination.

- We have a Data and Computing Working Group to help us move ahead.

The VxOs

- The Virtual Solar Observatory (VSO) came online in 2004
- The Virtual Space Physics Observatory (VSPO) in 2005
- Point out some other activities
  - GAIA - All sky cameras - Eric Donovan
  - Virtual Solar-Terrestial Observatory - Peter Fox
  - European Grid Solar Observatory - Bob Bentley
- Virtual Observatories have become a focal point of the eGY.
- We selected five new VxOs on April 10, 2006:
  - Virtual Heliospheric Observatory - Adam Szabo, PI
  - Virtual Magnetospheric Observatory/UCLA - Ray Walker, PI
  - Virtual Magnetospheric Observatory/GSFC - Jan Merka, PA
  - Virtual Radiation Belt Observatory - Bob Weigel, PI
  - Virtual ITM Obersatory - Dan Morrison, PI
- ROSES 2006 has a solicitation for new VxOs.

Heliophysics Recent & Upcoming Events

- **SET** (Space Environment Testbed) CDR at GSFC June 26-27, 2006
- **TWINS I (**Two Wide-angle Imaging Neutral-atom Spectrometers) has launched.
- **SDO** (Solar Dynamics Observatory**)** Independent Annual Review with LWS IRT on June 28-29, 2006
- **RBSP** (Radiation Belt Storm Probes**)**& associated MOO selection is imminent. **ITSP** will be looked at after RBSP selection.
- **Solar Sentinels SDT** report available on line.
- **STEREO** (Solar TErrestrial Research Observatory)
  - LRD 8/20/06
- **SOLAR-B**
  - Transport to launch site ~8/5/06
  - LRD 9/23/06

- **AIM** (Aeronomy of Ice in the Mesosphere) LRD 9/29/06 (Under Review)
- **THEMIS** (Time History of Events and Macroscale Interactions during Substorms) LRD 10/19/06
- **IBEX** (Interstellar Boundary Explorer) Mission CDR 9/2-15/06
- **Bilateral** with ESA on Solar Orbiter/Solar Sentinels 6/27-6/29
- **ILWS** Working Group meeting in China 7/22-7/23
- **C/NOFS/CINDY** Launch in 2007?

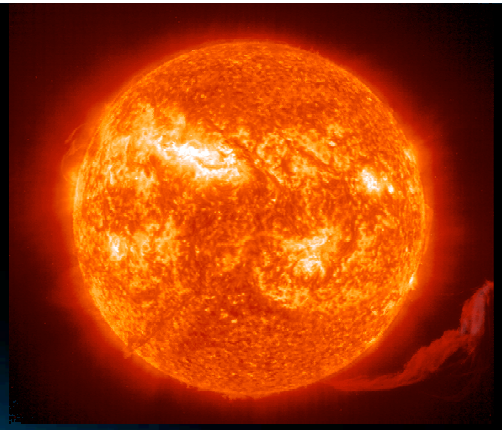
HELIOPHYSICS DIVISION
OPERATING MISSION ASSESSMENT

Mission	Launch	Phase	Extension to	Mar	Apr	May	Jun	Mission or Program Status
Polar	2/24/96	Extended	March 2007					
Ulysses	10/06/90	Extended	March 2008					
FAST	8/21/96	Extended	July 2008					
Geotail	7/24/92	Extended	July 2008					
TRACE	4/01/98	Extended	Nov 2008					
Cluster	7/16/00	Extended	~ 2010					
ACE	8/27/97	Extended	> 2011					
RHESSI	2/05/02	Extended	> 2011					
SOHO	12/02/95	Extended	> 2011					
TIMED	12/07/01	Extended	> 2011					
Voyager 1 + 2	8/20/77	Extended	> 2011					
Wind	11/01/94	Extended	> 2011					
GSFC Multimission project								Funding sharply reduced in FY-07

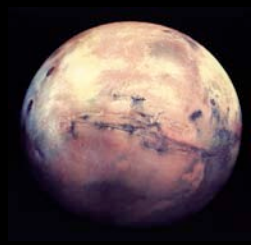
Progress according to plan
All commitments can be met

Area of concern
Problem can be resolved within reporting organization
Needs attention

Significant problem
Solution not identified
Needs action/help beyond reporting organization

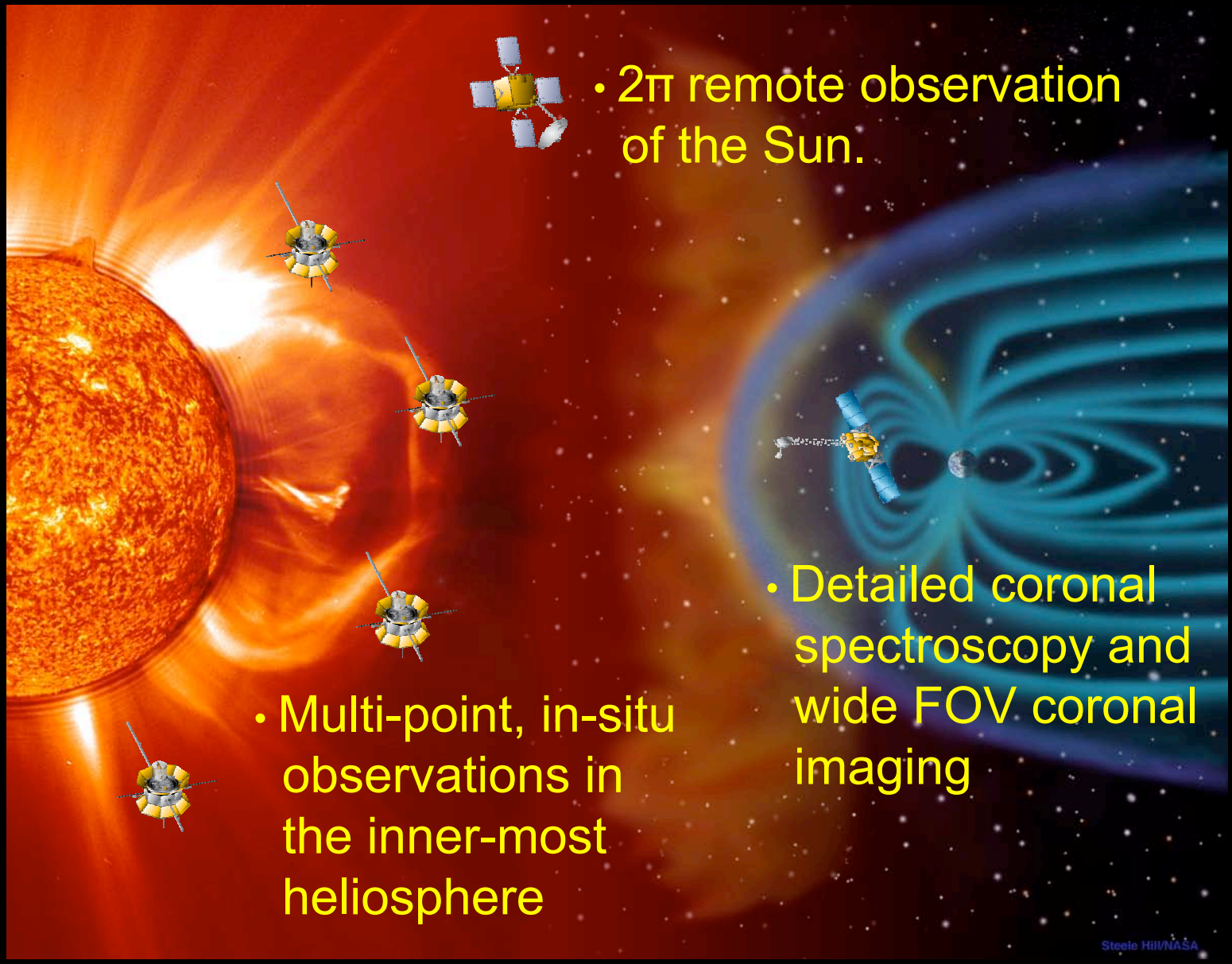


Sentinels in Exploration



- Determine where, when and how are solar energetic particles (SEPs) accelerated.
- Determine how energetic particles propagate and and are modulated.
- Characterize the interplanetary environment (worse case scenarios)
- Develop forecasting capabilities for Earth, Mars and for spacecraft in transit.

Sentinels Mission Architecture

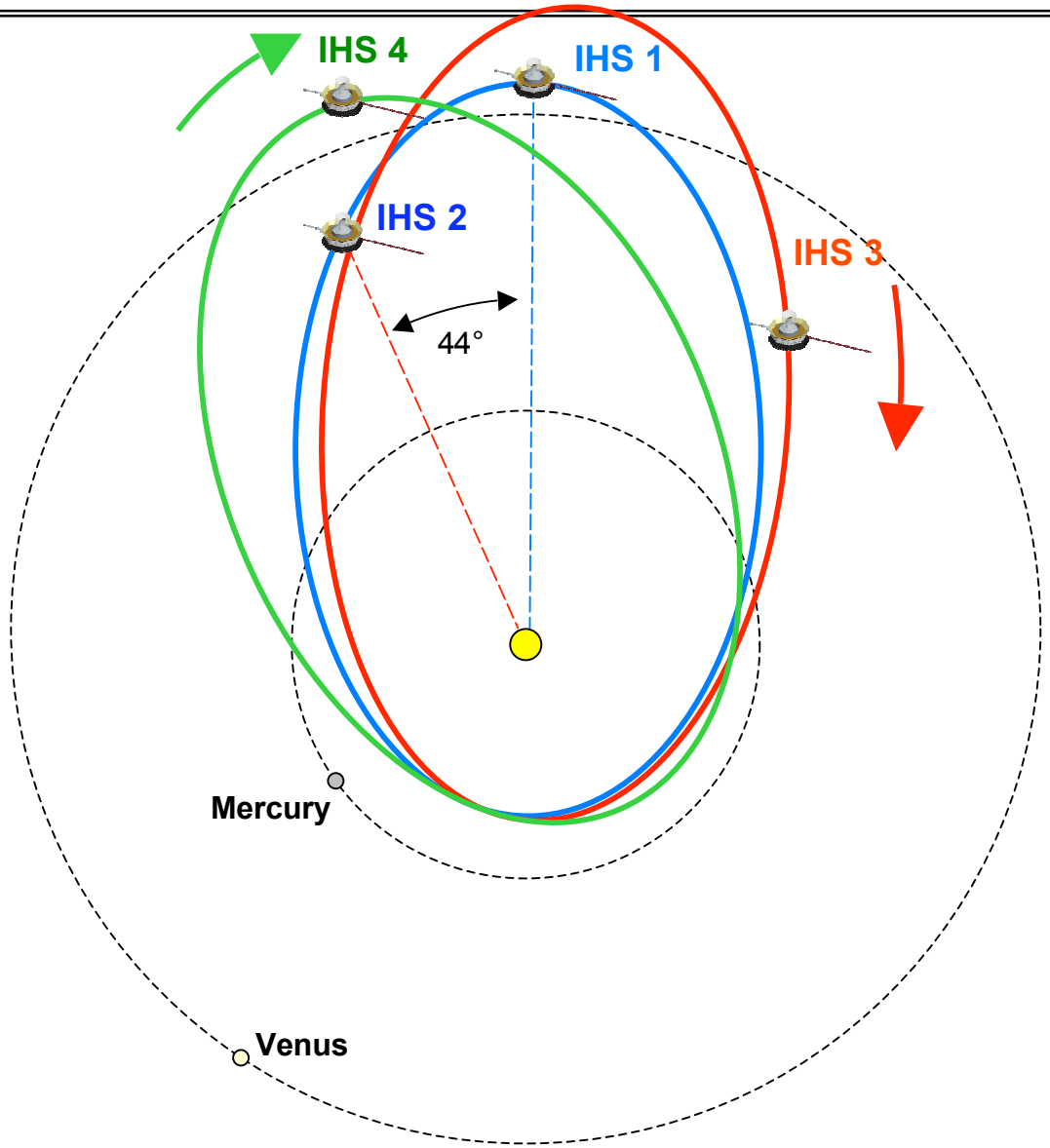


Mission Requirements

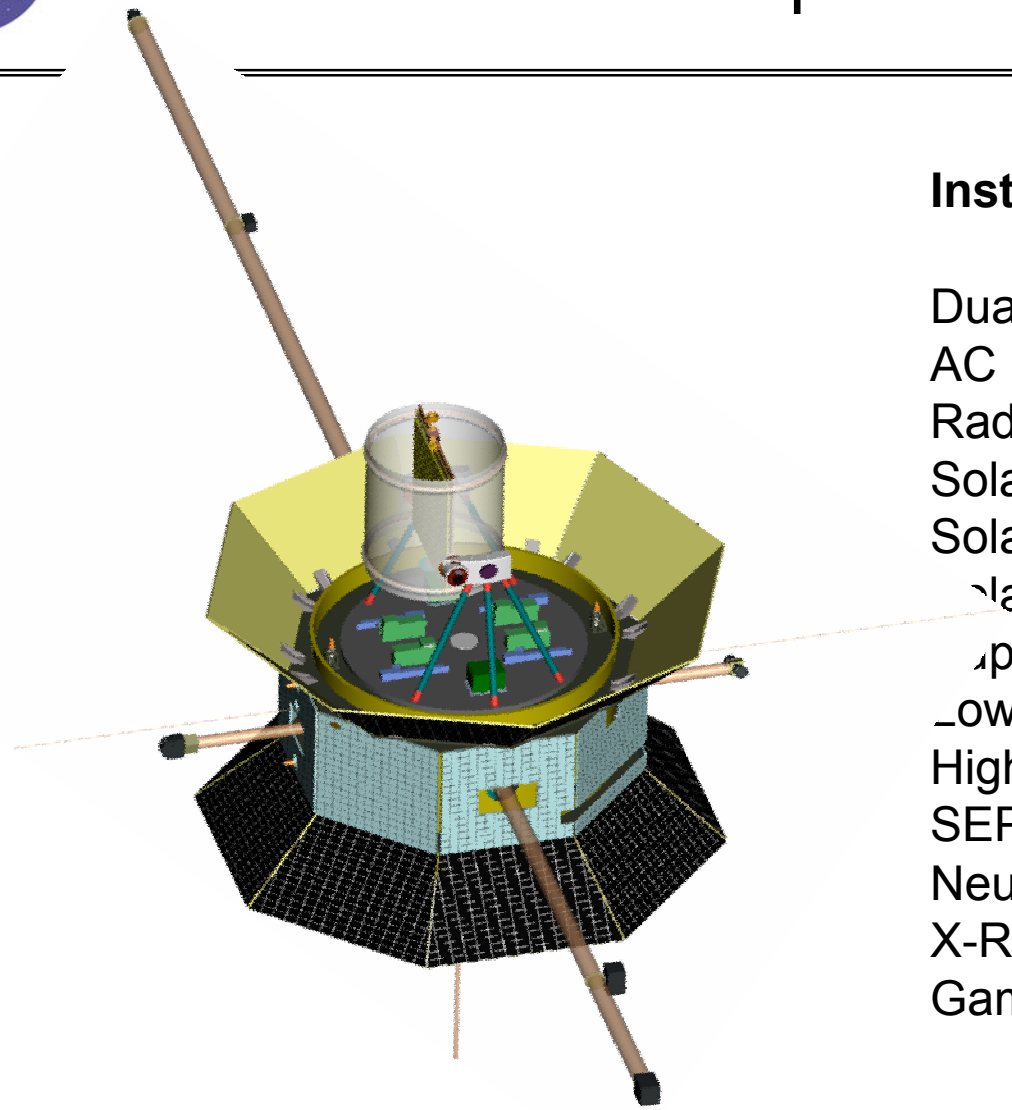
- **Inner Heliospheric Requirements**
  - Close to the Sun: 1-2 SEP mean-free-paths (<0.3 AU)
  - Sufficient duration: 10s of SEP events (> 30% duty cycle below 0.3 AU)
  - Minimum of 4 s/c for CME geometry and SEP field line connection
  - Single launch
  - $C_3 < 30\ km^2/s^2$
- **In-situ and Imaging Observation Overlap**
  - Duration: > 1 year
  - FOV: Coronagraph FOV ~0.3 AU (60 Rs)
- **Far Side Requirements**
  - ~1 AU orbit
  - ~ 2 year beyond 60° Earth-Sun-S/C angle
  - ¬ Short cruise

Inner Heliospheric Orbit Design

- 3 Venus gravity assists for each spacecraft
- Final orbits: 0.25 x 0.76 AU
- Orbital periods: 127-137 days
- Cruise: 2 yr 3-11 months
- Launch opportunities: March 2012, Feb 2014, Sept 2015, March 2017



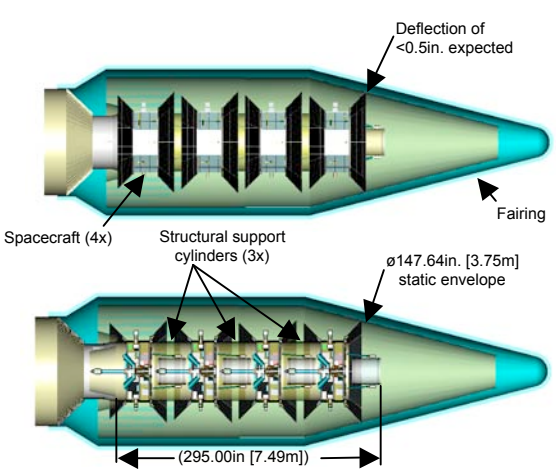
Inner Heliospheric Sentinels



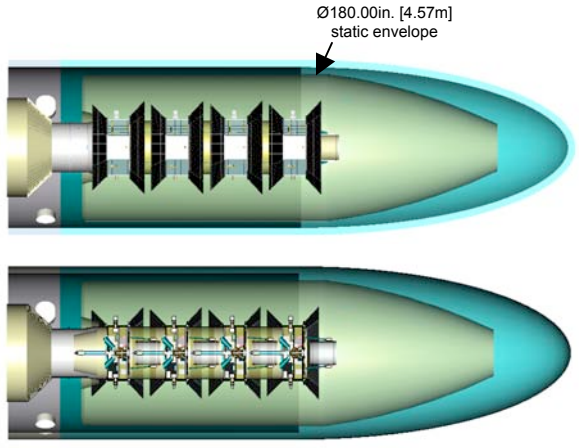
Instruments

Dual Magnetometer
AC Magnetic Fields Search Coil
Radio Science
Solar Wind Ions
Solar Wind Electrons
Solar Wind Composition
Suprathermal Electrons and Ions
Low Energy Ions and Electrons
High Energy Ions and Electrons
SEP Charge State
Neutron Spectrometer
X-Ray Imager
Gamma-Ray Spectrometer

IHS Launch Configuration



a)



b)

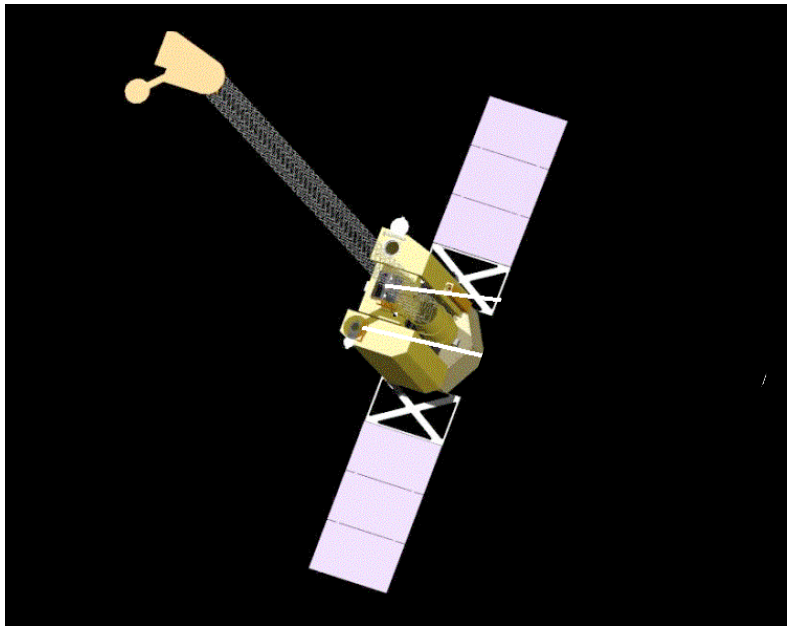
The four Inner Heliospheric Sentinels spacecraft stowed in (a) the 4-m fairing on an Atlas V-431 and (b) the 5m fairing of an Atlas V-541.

Near-Earth Imaging Sentinel

- Sun-sync Earth orbit.
- Significant overlap with IHS and SDO.
- Instrumentation:

  Inner Coronagraph (1.3 – 5 Rs)
  Outer Coronagraph (4 – 55 Rs)
  UV Spectroscope

- Similar concept previously proposed under Midex.

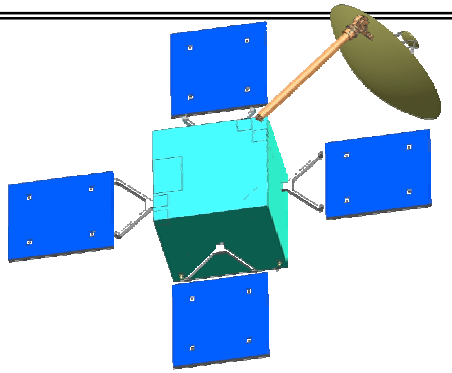


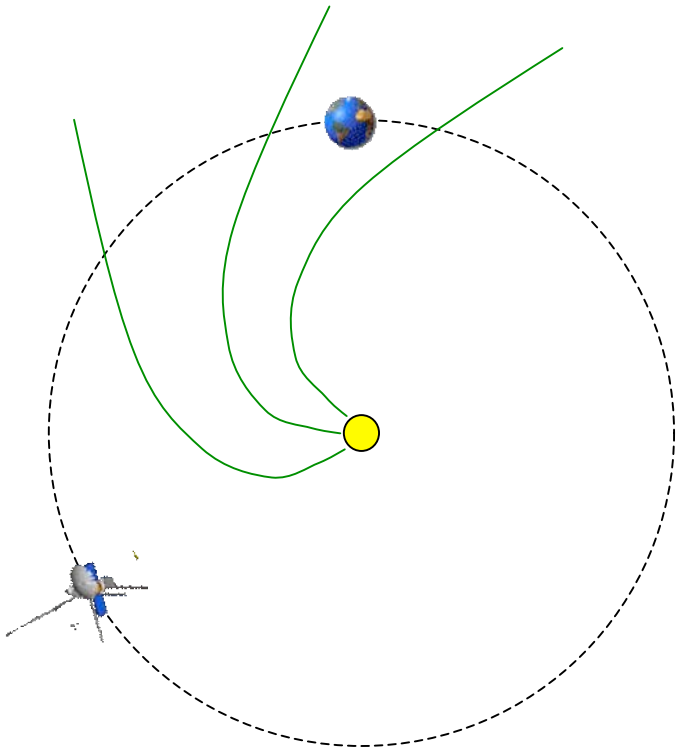
Far Side Sentinel

- 1 AU orbit, 120° - 180° leading Earth.
- Taurus launch.
- Total launch mass: 250-350 kg
- Significant overlap with IHS and Solar Orbiter.
- Instrumentation:

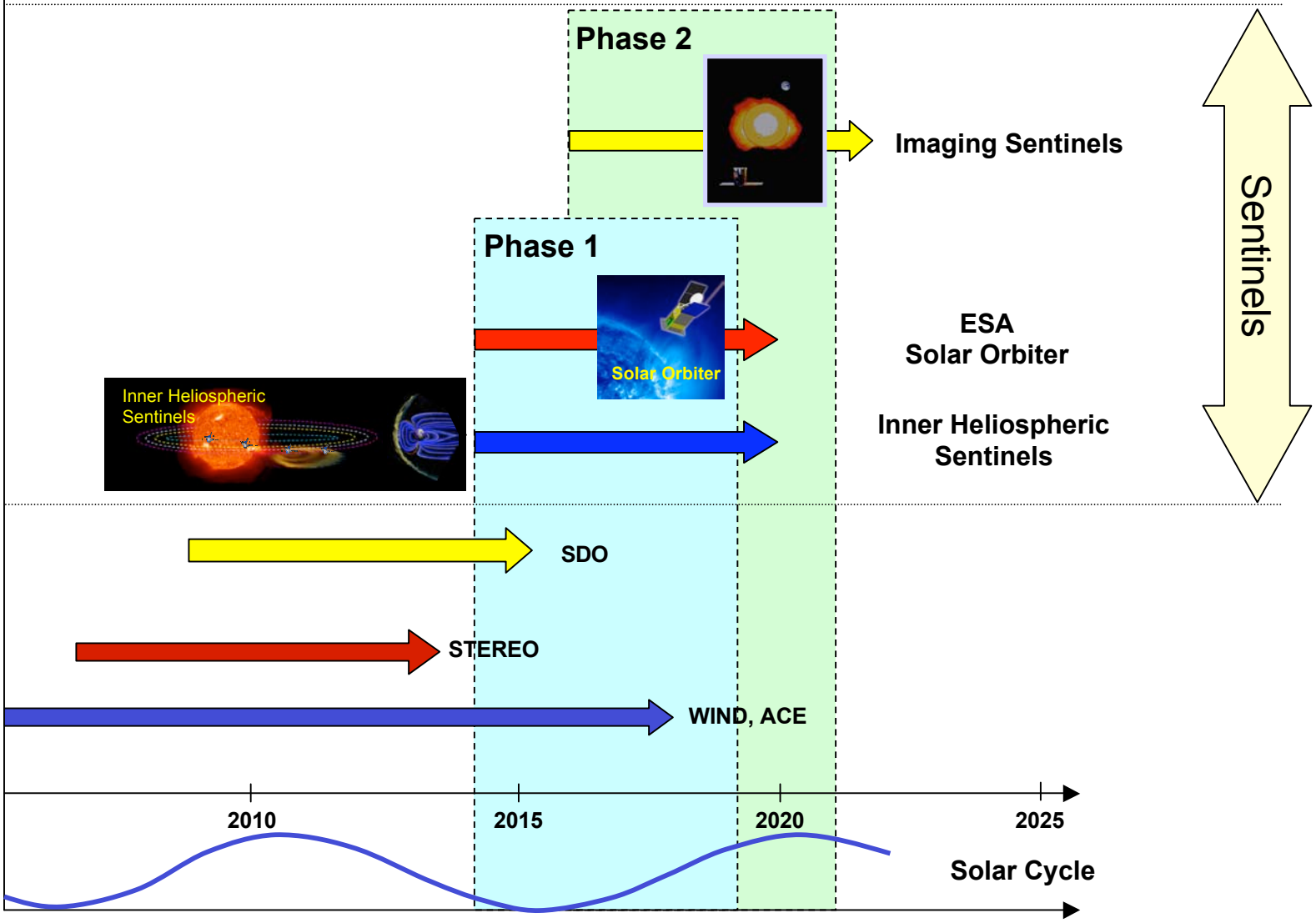
  Full Disk Magnetograph

  Optional small in-situ package

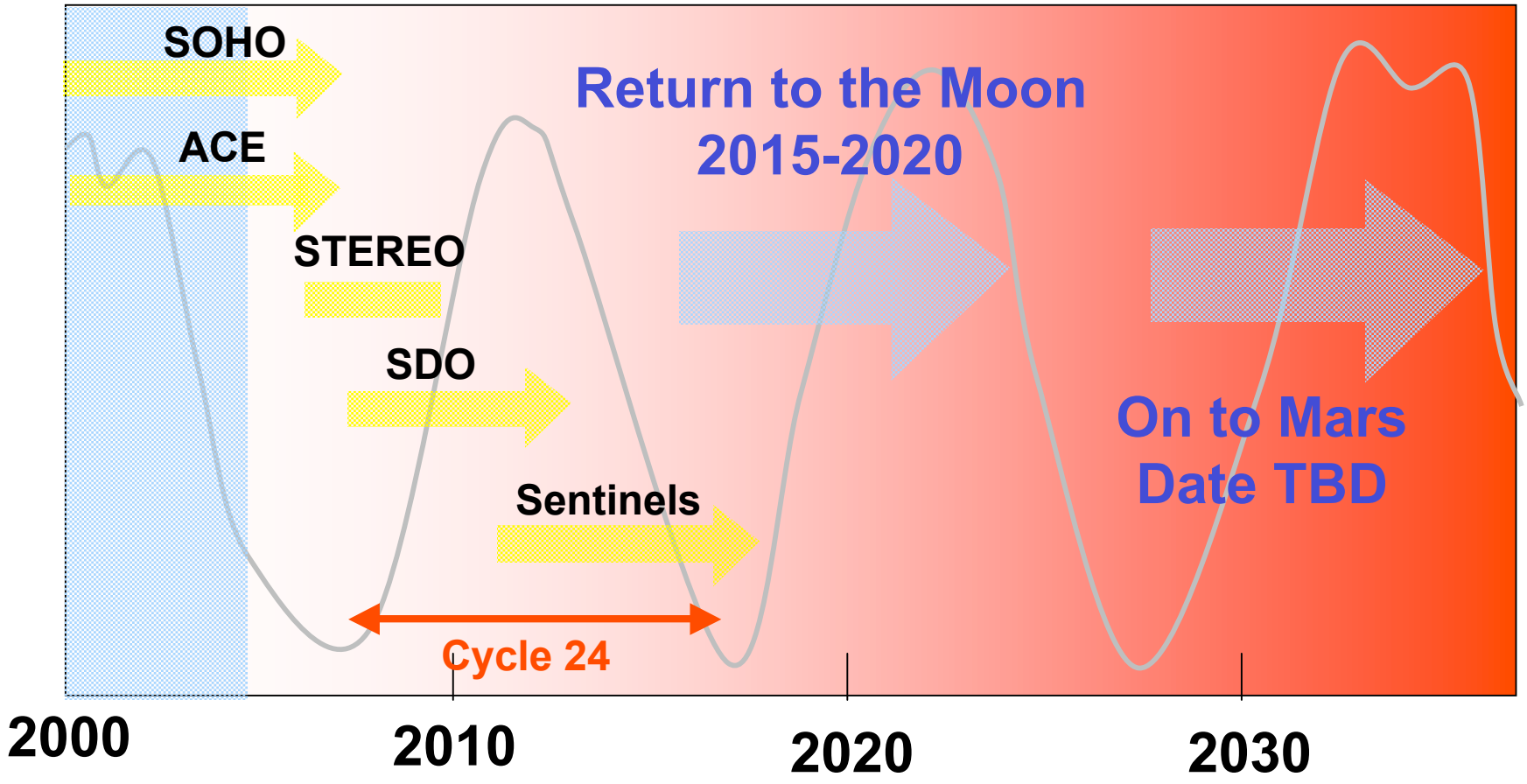




The Phases of Sentinels



Timing of Sentinels



Only One More Solar Cycle Left to Learn What We Must Learn

Science Budget Strategy

- To support Space Operations Mission Directorate requirements within a fixed Agency budget, reductions to previous Science planning are necessary

- Science gets 1.5% growth from FY06 to 07, 1% per year thereafter
  - $3.1B decrease from FY06 Budget runout

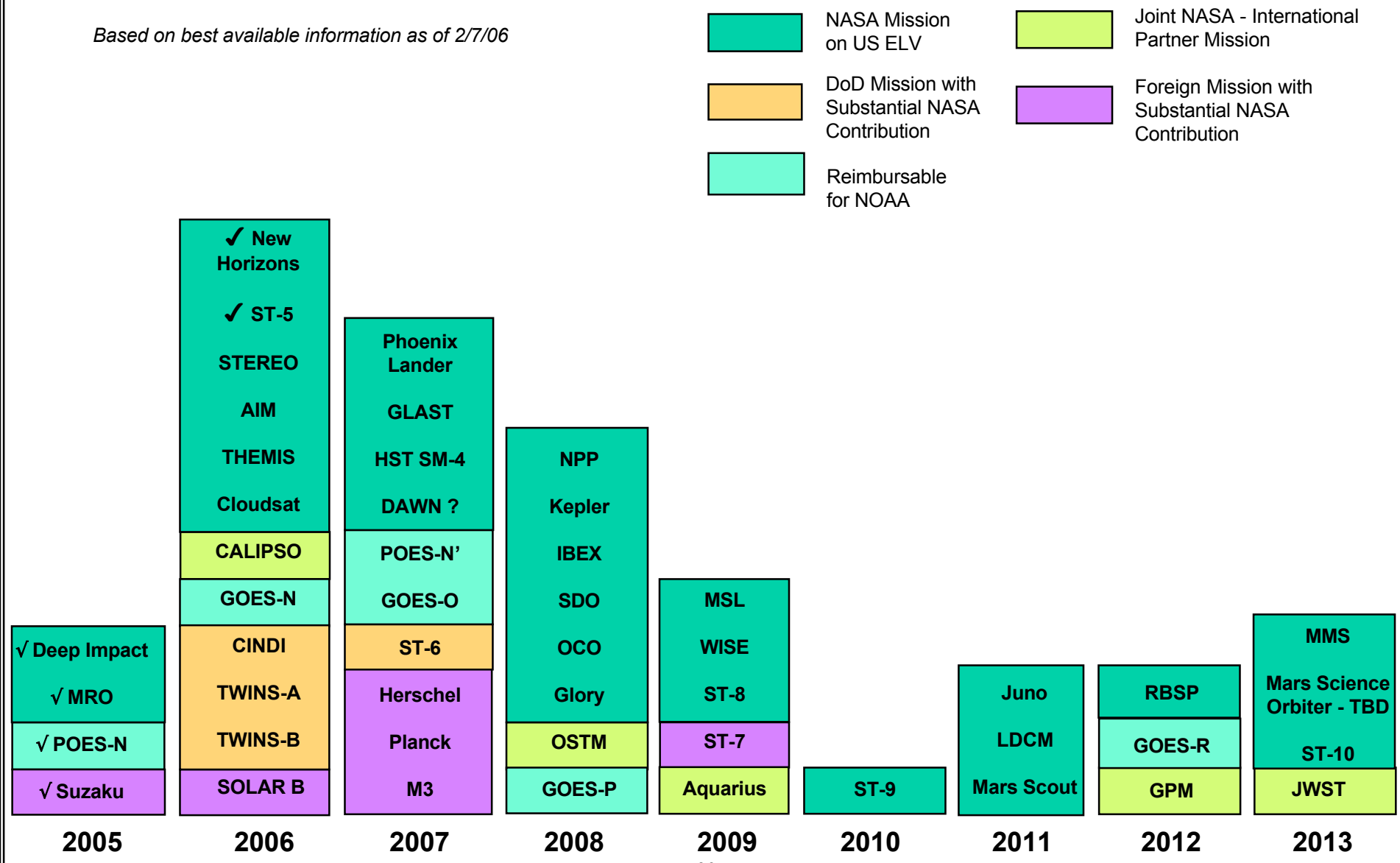
- Strategy for Adjustments
  - Develop an executable program based on strategic National Academy science priorities

Heliophysics FY07 Budget

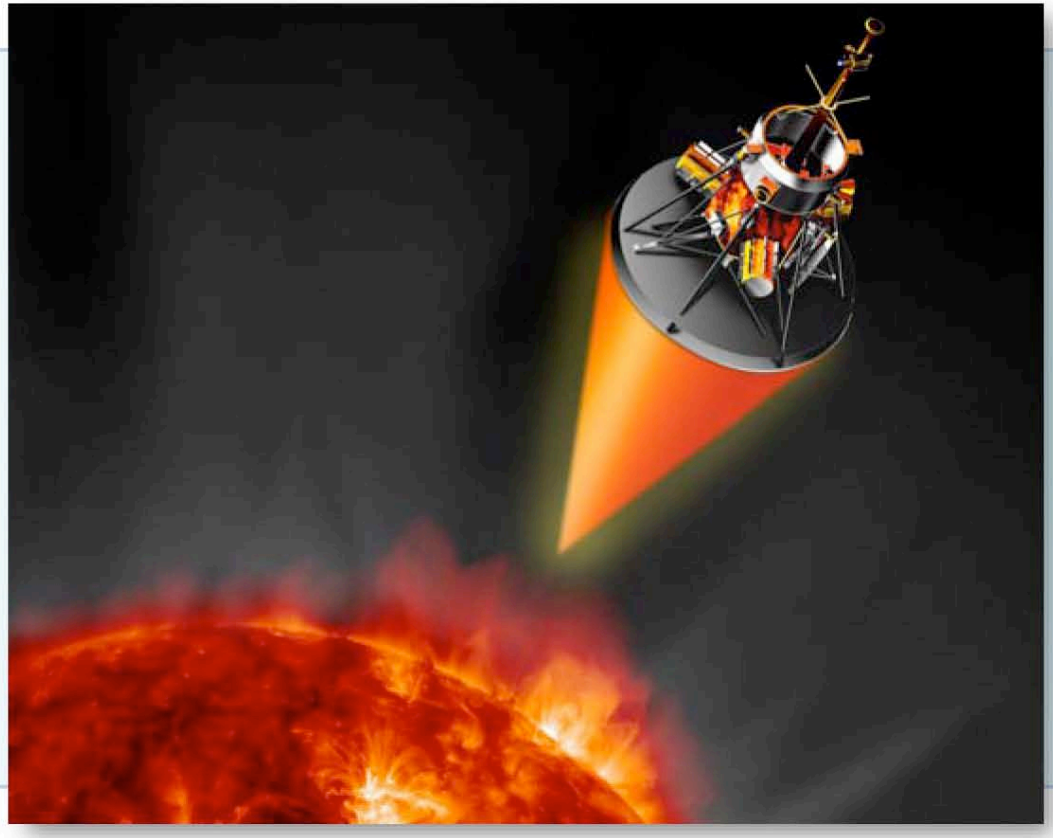
	FY06	FY07	FY08	FY09	FY10	FY11
FY 07 Heliophysics Budget	723.6	679.9	813.0	824.5	800.0	852.1
Living with a Star Program	239.2	226.3	264.2	270.6	245.8	276.3
Solar Terrestrial Probes Program	94.4	84.1	182.4	197.2	106.0	122.4
Explorer Program	129.9	73.4	73.3	91.1	174.1	182.3
Heliophysics Research	195.4	205.7	192.3	179.5	188.0	183.0
R&A	31.8	30.7	30.7	31.5	30.7	30.7
Operating Missions / Data / Modeling	109.2	103.4	100.1	94.5	103.8	110.8
Sounding Rockets	39.5	41.6	41.5	41.5	41.5	41.5
GSFC Building Support	14.9	30.0	20.0	12.0	12.0	
Heliophysics Technology - New Millenium	64.7	90.4	100.8	86.2	86.1	88.1

NASA Science Mission Launches (CY05-CY13)

Based on best available information as of 2/7/06



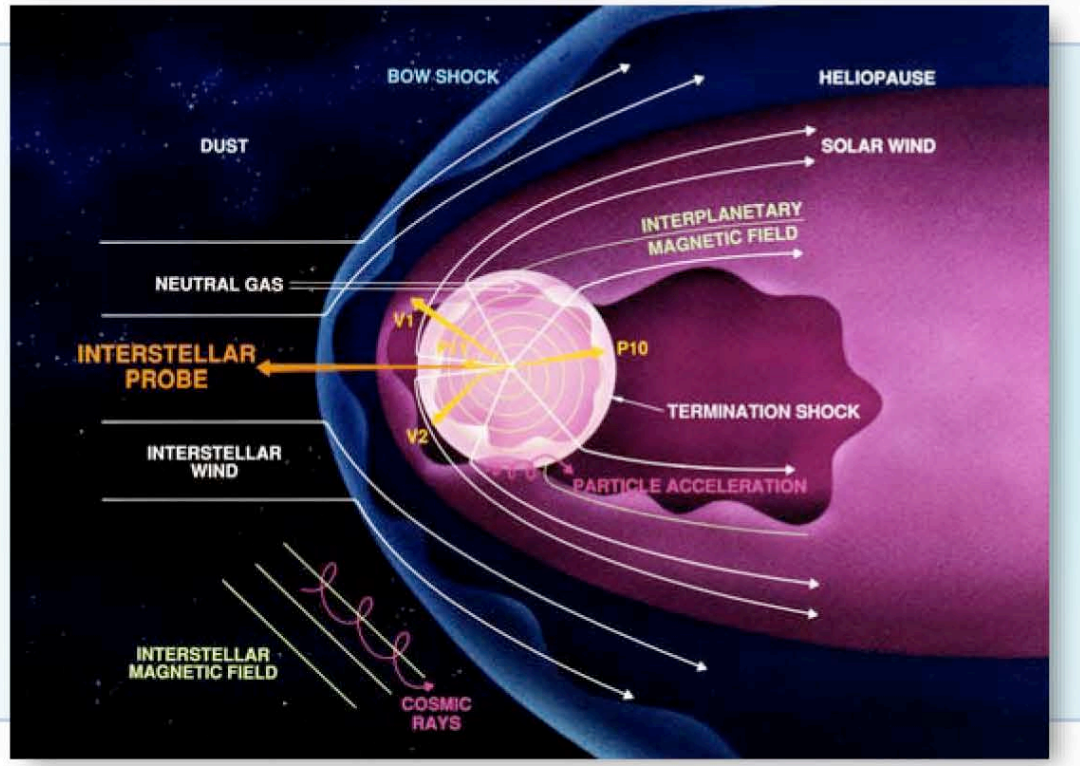
NEAR/INTERMEDIATE-TERM



Solar Probe

- Measure magnetic reconnection at the Sun in the corona
- Thermal shielding protection for in situ solar wind measurement at 4Rs

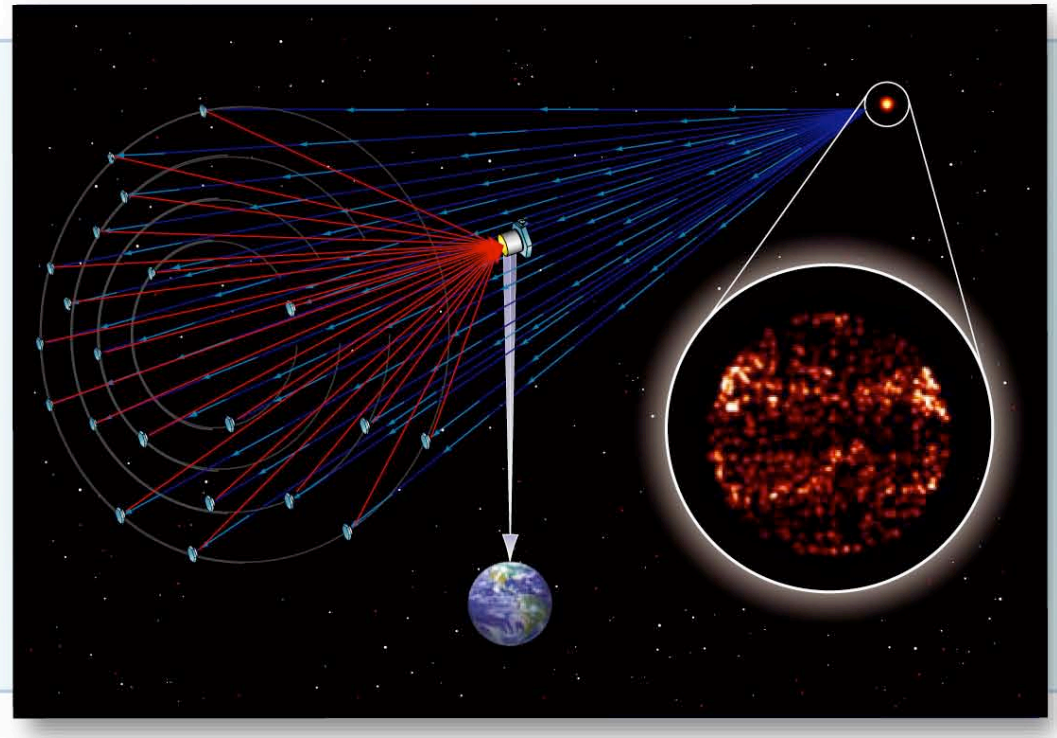
FUTURE



Interstellar Probe

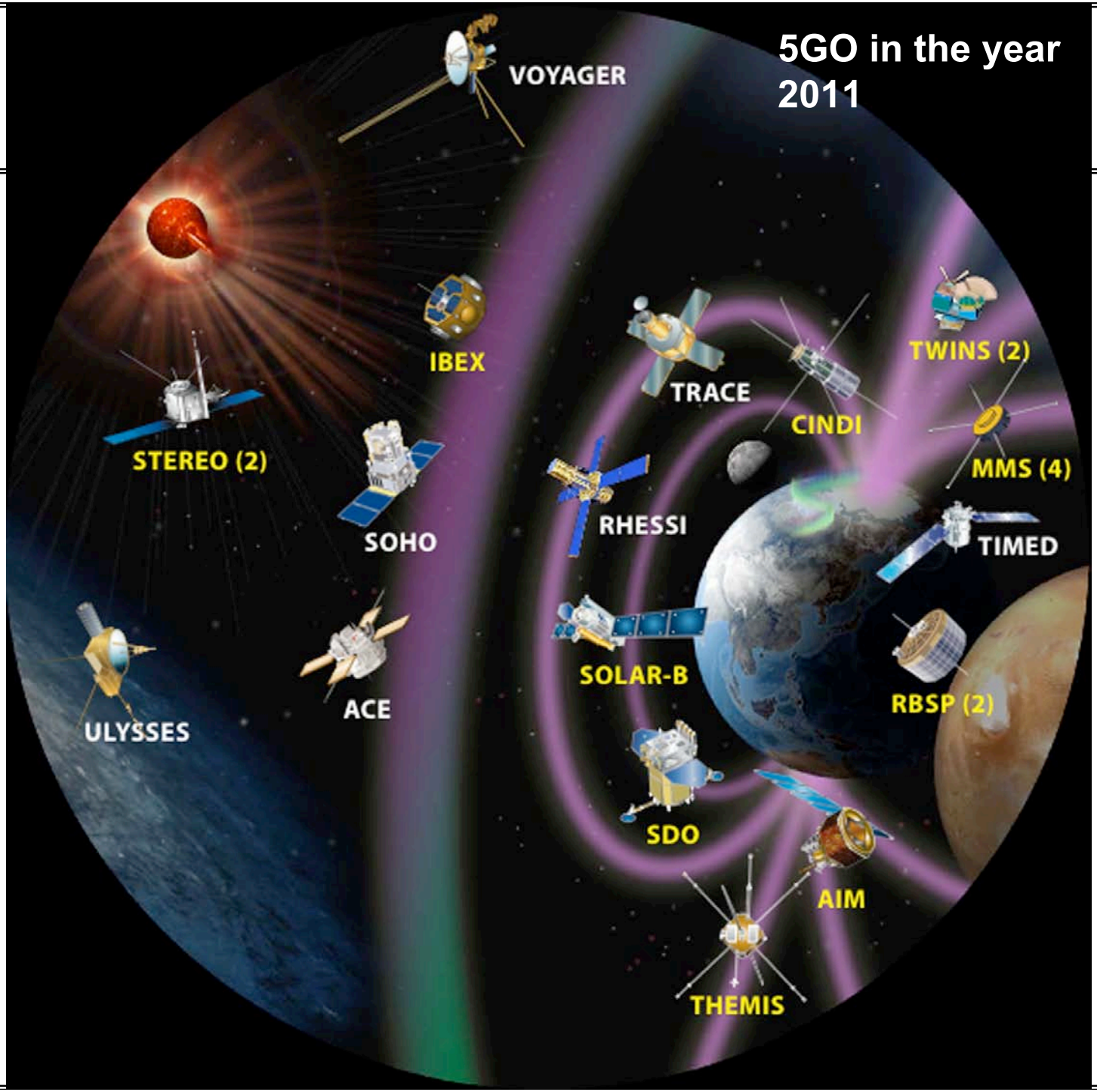
- Analyze the first direct sample of the interstellar medium
- Advanced propulsion for 200AU in 15 years

FAR-TERM



Stellar Imager

- Image activity in other stellar systems
- UV interferometry in space with precision formation flying autonomous constellation


5GO in the year 2011
VOYAGER
IBEX
STEREO (2)
SOHO
ACE
ULYSSES
TRACE
CINDI
TWINS (2)
MMS (4)
RHESSI
TIMED
SOLAR-B
RBSP (2)
SDO
AIM
THEMIS